IN-46
028571

Final Technical Report for
NASA Grant: NAG 5-4067

"Theoretical Investigation of the High-Altitude Cusp Region Using Observations from Interball and ISTP Spacecraft"

03/01/97 - 10/31/98

P.I.: Maha Ashour-Abdalla
University of California at Los Angeles

A fundamental goal of magnetospheric physics is to understand the transport of plasma through the solar wind-magnetosphere-ionosphere system. To attain such an understanding, we must determine the sources of the plasma, the trajectories of the particles through the magnetospheric electric and magnetic fields to the point of observation, and the acceleration processes they undergo enroute. This study employed plasma distributions observed in the near-Earth plasma sheet by Interball and Geotail spacecraft together with theoretical techniques to investigate the ion sources and the transport of plasma. We used ion trajectory calculations in magnetic and electric fields from a global MHD simulation to investigate the transport and to identify common ion sources for ions observed in the near-Earth magnetotail by the Interball and Geotail spacecraft. Our first step was to examine a number of distribution functions and identify distinct boundaries in both configuration and phase space that are indicative of different plasma sources and transport mechanisms.

We examined events from October 26, 1995, November 29-30, 1996, and December 22, 1996. During the first event Interball and Geotail were separated by ~ 10 R_E in z, and during the second event the spacecraft were separated by ~ 4 R_E. Both of these events had a strong IMF B_y component pointing toward the dawnside. On October 26, 1995, the IMF B_z component was northward, and on November 29-30, 1996, the IMF B_z component was near 0. During the first event, Geotail was located near the equator on the dawn flank, while Interball was for the most part in the lobe region. The distribution function from the Coral instrument on Interball showed less structure and resembled a drifting Maxwellian. The observed distribution on Geotail, on the other hand, included a great number of structures at both low and high energies. During the third event (December 22, 1996) both spacecraft were in the plasma sheet and were separated by ~ 20 R_E in the y direction. During this event the IMF was southward.

Summary of our findings

1. October 26, 1995

- We found that the ions measured at Geotail originated from three different source regions: the dawnside low latitude boundary layer (LLBL), the ionosphere, and the dayside magnetopause. Because the IMF was northward, some particles entered from the high-latitude reconnection region. The structures seen in the observed distribution function can be mapped to the source regions supplying the plasma at the structure's phase space location.

The high energy portion of the observed Geotail distribution was supplied by the dawnside LLBL. These particles were strongly non-adiabatic. The peaks in the middle of the distribution were also from the LLBL but from further downtail. These particles were transported earthward without being significantly energized. The lower energy part, however, is a mixture of ionospheric and LLBL ions from the dayside.

- In contrast, all of the particles measured at Interball entered on lobe fields lines. This mechanism is consistent with fresh plasma entering the magnetosphere, as the particles had not yet interacted with the current sheet. Interball was far above the plasma sheet in the lobe region, and the ions that entered the magnetosphere on these lobe field lines moved straight to the spacecraft.
- Only a few particles seen by Interball and Geotail shared the same source region.

2. November 29-30, 1996

During this event, the two spacecraft were close together in the near-Earth plasma sheet. Geotail was around –25 R_E just dawnward of midnight near the equatorial plane, and Interball was also in the plasma sheet and about 4 R_E duskward of Geotail. We examined three distribution functions for this event, at 2340 UT on November 29, and 0200 and 0640 UT on November 30, and found that Interball was on closed field lines, and Geotail was near the boundary between open and closed field lines during the 0200 UT time interval. Geotail saw only particles coming from the dawnside LLBL whereas Interball saw particles from both sides that were transported on closed field lines. Thus, even though the satellites were only 4 R_E apart, with most of this separation in the y direction, they shared only part of the source region, though more than in the previous event.

3. December 22, 1996

During this event, the Wind spacecraft located 83 R_E upstream measured a positive B_x component and through the initial two hours of the event (900-1100 UT) observed a negative (dawnward) B_y component. B_z was southward for the first hour of the interval but then gradually decreased to nearly zero between 1000 and 1100 UT. The solar wind velocity V_x was 400 km/s and the density was 4 cm^{-3}.

- At the beginning of the interval both the MHD model and observations indicate that Geotail was in the northern lobe. Between 1000 and 1100 UT Geotail slowly moved from the lobes to the plasma sheet. On the other side of the magnetosphere, Interball remained in the lobe until approximately 1000 UT. Then between 1000 and 1100 UT it slowly moved into the central plasma sheet, reaching the CPS after 1100 UT. Both satellites moved into the plasma sheet towards the CPS. This movement was most likely a response of the overall magnetosphere to the IMF, especially the B_y and B_x components.

- During the next two intervals, from 1100-1200 and 1200-1300 UT, the spacecraft were in a region where they could observe the temporal changes occurring in the magnetosphere. In these intervals both Interball and Geotail were near interesting dynamics that were occurring in the tail: at 1240 UT a small neutral line and reconnection region formed on the dawnside in the tail. For the first few minutes a region of tailward velocity expanded tailward. Geotail saw a slight increase in the V_X component but not much else.

- During the 1200-1300 UT interval Geotail entered the lobe and viewed something resembling a traveling compression region. A second reconnection event occurred at 1252 UT on the duskside, earthward of Interball. The simulation shows that Interball passed through the central part of the flux rope associated with a small reconnection event while the data indicate it encountered the edge of the flux rope. After the flux rope passed (1316 UT), Interball moved to the lobe field lines in both the simulation and observations.

- Both spatial and temporal effects are evident during the interval from 1200-1300 UT. The motion of the magnetotail placed Geotail away from the region where it previously saw flux ropes. On the other hand, in this event a small reconnection event occurred earthward of Geotail. The plasma sheet then passed beneath the spacecraft, and Geotail just missed detecting it. Fortunately, Interball was perfectly situated to catch the second reconnection event that occurred.

Presentations

1. Ashour-Abdalla, M., M. El-Alaoui, V. Peroomian, J. Raeder, L. A. Frank, W. R. Paterson, S. Kokubun, .T. Yamamoto, A. Fedorov, L. Zelenyi, K. W. Ogilvie, and R. P. Lepping, Correlative studies of plasma distributions observed by the Geotail and Interball spacecraft, 1997 IAGA Assembly, Uppsala, Sweden, August 4-15, 1997. (Abstract, p. 263).

2. Ashour-Abdalla, M., Sources and transport of plasma in the magnetosphere, Department of Geophysics, Beijing University, Beijing, China, April 1998.

3. Ashour-Abdalla, M., M. El-Alaoui, J. Berchem, and R. J. Walker, Using multi-point measurements to address space-time-ambiguities, AGU, San Francisco, CA, Dec. 6-10, 1998 (*EOS Trans. AGU, 79*(45), F749).

Publications

1. Ashour-Abdalla, M., M. El-Alaoui, J. Berchem, and R. J. Walker, Using multiple spacecraft observations and simulations to determine magnetospheric dynamics, *J. Geophys. Res.*, to be submitted.